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by

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for a

SYSTEM AND METHOD FOR WIRELESS CALL HANDOVER FROM A SHARED NETWORK TO A HOME NETWORK

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SYSTEM AND METHOD FOR WIRELESS CALL HANDOVER FROM A SHARED NETWORK TO A HOME NETWORK

BACKGROUND

Field of the Invention

[0001] The present invention relates generally to wireless communications. More specifically, the present invention relates to managing communication links to a wireless device during movement of the device between locations that are served by different network service providers.

Background of the Invention

[0002] Global system for mobile communication (GSM), one of the most widely used wireless access systems in today's market, employs so-called "cell" technology. Each cell contains a base transceiver station (BTS) to receive and broadcast radio frequency signals to the wireless communication device, such as a cell phone, personal digital assistant (PDA), or computer, all of which may be referred to as a mobile station (MS). In many geographic areas, particularly cities and metropolitan areas, more than one service provider of cellular communications may operate, each operating its own BTS, and base station controller (BSC), the latter often responsible for managing several BTS sites. Under normal conditions, a Mobile Switching Center (MSC) belonging to a customer's (subscriber's) operator is alerted to the location of the MS when the device is powered on. When a subscriber places a call within a region where her or his service provider operates (home region), the call is routed through the provider's network, which is sometimes referred to as a home public land mobile network, or HPLMN. The call is thus routed to the nearest BTS in the HPLMN, even if a BTS from another service provider is available. Thus, all the revenues associated with the call are realized by the subscriber's service provider.

[0003] However, there are many geographical areas where a typical service provider may not have a license to operate over the necessary frequency spectrum, or where it would be unduly expensive to deploy network resources, in light of the volume of calls generated. This situation might apply, for example, along major interstate freeways or in very rural areas, among others. In such areas, a service provider will often enter into a sharing agreement with another provider (partner) to receive access to coverage of the area for its customers. The shared network area (hereafter termed "partner region") is designated as belonging to the partner and calls operating in the area are routed through the partner's network. In GSM, if a subscriber

moves from an HPLMN into a partner region, GSM has the mechanisms in place to hand the call into the partner network.

[0004] As illustrated in Figure 1, as MS **2**, belonging to a subscriber to a home network, travels through home region **4**, including cells **6** and **8**, the call is directed to and from a BTS in cell **6**, which is operated by the home network. During travel, MS **2** continues to monitor the frequencies of channels associated with nearby cells, to determine the signal strength of nearby BTS units (hereafter simply referred to as "cells"). This information is transmitted to the BSC (not shown), which instructs the MS to hand the call into a second cell **10**, based on the cell signal strength, and other factors related to management of call traffic. As MS **2** continues to travel to the border of home region **4,** the MS will monitor the signal strength of nearby cell **16**. Because there are no nearby cells of the home network, a handoff will occur into cell **16** of partner region **14** if MS **2** continues to travel in the same direction. Also, if MS **2** is located in partner region **14** operated by the partner network, a new incoming call is automatically routed to the subscriber MS **2**, through cell **16** of the partner network.

[0005] When MS **2** moves back to the border of a home region **20**, there is no general mechanism to route the call back to the home network without creating artificial boundaries (i.e. MSC borders). In Figure 1, home region **20** contains cells **22** and **24** belonging to the home and partner networks, respectively. Upon reaching a region between cells **16** and **20**, MS **2** continues to send information regarding nearby cells to the BSC of the partner network, which instructs the MS to hand the call into a new cell. In routing the call through a nearby cell, the BSC knows to which network the cell belongs, but not to which network the MS/subscriber belongs. In the example shown in Figure 1, the call is handed into cell **24**, operated by the partner network, based on slightly higher signal strength than cell **22**. Path **28** indicates the succession of cells handling the call from MS **2**, as it travels along path **3**. When MS **2** emerges into home region **20**, rather than having the call routed through the home network cell **22**, it remains routed through partner network cell **24**. MS **2** then arrives at a location **26**, where the call continues until termination. Although the signal strength of cell **22** may be more than sufficient to carry the call, the partner network continues to carry the call for its duration. This results in a loss of potential revenue to the home network operator for the duration of the call that takes place while the subscriber has entered the home region **20**, but is routed through the partner network. Thus, the lack of means to direct a call handled by a partner back into a home network may result in significant lost revenue for an operator.

[0006] When viewed from the perspective of the partner network, the aforementioned scenario presents additional problems. Because of the inability to handover all

calls associated with home network subscribers back to a cell in the home network, when any MS from the home network, whose call is being routed through the partner network, enters region **20**, the resources of the partner network are unduly burdened with handling such calls that "should" be handed to the home network. This may result in inconvenience to, or lost revenue from, partner network subscribers who attempt to place calls in the region **20**.

[0007] While the above example was directed towards illustrating problems existing with handover of voice communications between networks, similar problems can occur for data transmission to and from a mobile station. Using general packet radio service (GPRS), data is transmitted to or from a mobile device connected to a GSM service provider. When an MS belonging to a subscriber is in a partner region and approaches the border between a partner region and home region during a GPRS message, handoff to the home network is desired.

[0008] It is thus clear that there is a need to establish a system and method for communication between different mobile networks, where a call handled by a partner network can be handed back to the home network, as opposed to any other available network, when an MS enters a home region.

BRIEF SUMMARY OF THE INVENTION

[0009] The present invention provides systems and methods for routing mobile communications during travel of a MS from a partner network region to a home region. In a first embodiment, a method is disclosed in which a handover from a partner network to a subscriber's home network is accomplished by the partner network's setting of a flag indicating that a call belongs to a subscriber to a home network, when it first handles the subscriber's call. The flag may be a number, code or any other information that designates the subscriber as being associated with a particular network provider. When the MS of the subscriber approaches the home region, the partner network is signaled by the previously set flag to initiate a handover of the customer's call back to the home network. This functionality is also referred to as "differential handover".

[0010] In another embodiment of the present invention, a method is disclosed in which a differential handover from a partner network to a home network is accomplished by the sharing of network specific data between the home network and partner network, such as broadcast control channel (BCCH) frequency and base station (cell) identity codes (BSIC), in addition to setting of a flag denoting a home network subscriber when a call is first handled. When the partner network is signaled by the previously set flag to initiate a differential handover, the known frequency and cell parameters belonging to the home network can assist in directing the handover.

[0011] In a further embodiment, a method is disclosed in which a differential handover of a GPRS message from a partner network to a subscriber's home network is accomplished by setting a flag in a message received by the serving GPRS support node (SGSN) of the partner network, when it first handles a subscriber's message. The flag may be set based on a subscriber's international mobile station identity (IMSI), for instance. When the MS of the subscriber approaches the home region, the partner network is signaled by the previously entered flag to initiate a differential handover of the GPRS message to the home network.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Figure 1 is a schematic diagram of call handling for a traveling mobile station.

[0013] Figure 2 illustrates an embodiment of the present invention, in which differential call handover between networks occurs.

[0014] Figure 3 illustrates exemplary steps of a differential call handover according to an embodiment of the present invention.

[0015] Figure 4 illustrates exemplary steps of a differential call handover according to an alternative embodiment of the present invention.

[0016] Figures 5a and 5b illustrate differential call handover according to a further embodiment of the present invention.

[0017] Figures 6a and 6b illustrate differential GPRS handover according to a still further embodiment of the present invention.

[0018] Figure 7a illustrates exemplary steps of a differential GPRS handover according to a further alternative embodiment of the present invention.

[0019] Figure 7b illustrates exemplary steps of a differential GPRS handover according to another alternative embodiment of the present invention.

[0020] Figure 8 illustrates exemplary steps of a differential GPRS handover according to a still further alternative embodiment of the present invention.

[0021] Figure 9 illustrates exemplary steps of a differential GPRS handover according to a still another alternative embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0022] Before one or more embodiments of the invention are described in detail, one skilled in the art will appreciate that the invention is not limited in its application to the details of construction, the arrangements of components, and the arrangement of steps set forth in the following detailed description or illustrated in the drawings. The invention is capable of other

embodiments and of being practiced or being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

[0023] A preferred embodiment of the present invention comprises a method for differential handover of a call from a partner network to a home network, when, during travel, a mobile station moves between a region operated by the partner and a region in which both the partner network and home network operate. In particular, the handover from the partner network to the home network occurs when the MS subscriber is a customer of the home network. In order to ensure that the call is routed to the home network, a flag identifying the call as associated with the home network is set by an MSC of the partner network, in the partner networks BSC, when the call is first routed through the partner network. This could occur when a call is first initiated in partner region, or when an MS enters a partner region during an ongoing call.

[0024] Referring to Figure 2, when a mobile station **30** travels through partner region **32**, a call terminating at MS **30** is routed through MSC **34**, and BSC 36 belonging to the partner network. As MS **30** moves along path **28** through cells **42**, **44**, and **46**, associated with the partner network in partner region **32**, handover is accomplished by means well known to skilled practitioners. According to a preferred embodiment of the present invention, when MS **30** approaches the home region **50**, differential handoff of the call into cell **56** associated with the home network is performed, as opposed to a handoff into nearby cell **60** in the partner network, which also happens to operate in the same region.

[0025] Figure 3 illustrates details of steps involved in the differential handoff of a call according to a preferred embodiment of the present invention. In step **100,** MSC **34** in the partner network sets a flag that indicates MS **30** in region **32** is associated with the home network. The flag setting preferably occurs when MS **30** is in region **32** and initiates a call. Alternatively, the flag may be set when a call routed to MS **30** through the home network is handed over to the partner network, when MS **30** enters partner region **32**. In step **102**, MSC **34** then forwards the flag information to BSC **36** in the partner network. In a preferred embodiment, the flag information is inserted in a channel assignment message sent from MSC **34** to BSC **36** which allocates the frequencies for the call routed to MS **30**. The information contained in the flag will include an identifier such as the value "4", agreed upon by both networks, that is indicative of the subscriber's home network.

[0026] In step **104**, MS **30** approaches the edge of region **32** near the boundary of cell **46** (see Figure 2), and a measurement report for cell **46** is sent to BSC **36,** indicating that a

handoff to a new cell needs to be initiated. Since the call is flagged as being associated with the home network, in step **106** BSC 36 initiates a handover request to MSC **34** which forwards the handover request with flag " 4" to MSC **52** of the home network. MSC **52** then determines that the handover should be to cell **56.** In step **108** the MSC **52** forwards the required radio parameters associated with cell **56** to MSC **34.** In step **110** MSC **34** forwards the cell parameters to MS **30**, and handover from cell **46** to **56** is initiated.

[0027] In addition to a flag indicating that MS **30** belongs to the home network, differential call handover may be aided by sharing of control channel and system parameters between networks. Figure 4 illustrates details of steps involved in the differential handoff of a call according to a further embodiment of the present invention. Initial steps **100** and **102** are implemented as described above. In step **112**, the MS reports measurements of the BCCH frequency for cell 56. Since MS **30** is flagged, a handover request is subsequently initiated to MSC 52, through MSC 34 as indicated above, and described in more detail below. In a preferred embodiment, MSC **34** is provided with information stored in a database belonging to the partner network, including data associated with cells **56** and **58**, bordering on region **32,** illustrated in Figure 5a. When MS **30** approaches the edge of region **32** near the boundary of cell **46**, it receives and reports signal strength for nearby cells **56**, **58, 60** and **62**, as well as a report for cell **46**. This information is forwarded to MSC **34,** which ascertains, based on the report for cell **46,** that a handoff to a new cell needs to be initiated, shown as step **116**. Since the call is flagged as being associated with the home network, MSC **34** retrieves previously stored cell information corresponding to the flagged home network, and in step **118,** sends a message to BSC **36** indicating the relevant channels associated with the home network. In step **120**, the BSC **36** continues to monitor measurement reports sent by MS **30** as it travels toward home region **50**. The signal strength of cells reporting over the flagged home network channels are monitored to help identify a handover cell candidate. At step **122,** cells not associated with the home network are excluded as potential handover candidates. Thus, cells **60** and **62** are removed from the list of cells reporting further measurements and no longer are effectively detected by MS **30,** as shown in Figure 5b. If a cell is associated with the home network, e.g., cells **56** and **58** in home region **50**, then in step **124**, BSC **36** may send a handover request message to MSC **34**, indicating the channel/frequency parameters assigned to either of cells **56** or **58.** In step **126**, MSC **34** forwards the information received in a handover request message to MSC **50** in the home network. In step **128**, MSC **54** returns network resource information to MSC **34** to prepare for handover. In step **130**, MSC **34** directs MS **30** through BSC **36** to switch

to the appropriate frequency controlled by cell **56**, and the call becomes routed through cell **56** of the home network.

[0028] Embodiments of the current invention also include differential handover of GPRS transmissions. In Figure 6a, MS **30**, a subscriber to the home network, resides in partner region **32** operated by the partner network. GPRS data transmission to and from MS **30** is conducted through cell **70** linked to BSC **72**, which, in turn, is connected to serving GPRS support node (SGSN) **74**. Data traveling to and from the partner network, is linked to public data network **80**, e.g., the internet, through gateway GPRS support node (GGSN) **76**. Figure 7a outlines exemplary steps for differential handoff of a GPRS message from the partner network to the home network according to a preferred embodiment of the present invention. In step **200**, SGSN **74** receives information from MS **30**, including the international mobile system identity (IMSI). This information is forwarded to **BSC 72**, which sets a flag designating MS **30** as belonging to the home network, in step **202**. In step **204**, the home network also provides the partner network with BCCH frequency and BSIC information associated with the home network. This information is provided to the partner network in advance of the partner network handling a data exchange to or from MS **30**. As MS **30** travels toward home region **50** while transmitting and receiving GPRS data, the transmission is handed off to cell **78** in the partner network. In step **206**, SGSN **74** sends data to BSC **82**, which controls cell **78**, the data including the IMSI for MS **30**, with the flag identifying it as belonging to the home network. In step **208,** as illustrated in Figure 6b, MS **30** approaches the border between partner region **32** and home region **50**, and reports a signal strength of nearby cells. In step **210**, MS **30** receives BCCH information related to home network cells **88** and **90**. In step **212** MS **30** measures on cells **90** and changes over to cell **90** of the home network in step **214**. Alternativley, as illustrated in Figure 7b, handover to a home network may be effected without sharing of BCCH information with the partner network. After the partner network receives IMSI information from MS **30** and sets a flag in step **202**, an incoming call to MS **30** is flagged as belonging to the home network at step **216**. In step **218**, MS **30** approaches the border region between cells **78** and **90**, and BSC **82** transmits a packet cell change order to MS **30** indicating that it should look for home network cells for handover. In step **320** MS **30** hands into cell **90** of the home network.

[0029] Figure 8 illustrates exemplary steps for differential handoff of a GPRS message from the partner network to the home network according to another embodiment of the present invention. In the embodiment disclosed in Figure 8, no specific network information is shared between the home and partner networks, in advance of the time in which differential handoff is to take place. In step **300,** BSC **72** receives information from MS **30**, which has

entered partner region **32** during a call, or has received or initiated a call while residing therein. This information includes the international mobile station identity (IMSI), which is forwarded to SGSN **74,** which flags the call as belonging to a subscriber to the home network in step **302**. As MS **30** travels toward home region **50** while transmitting and receiving GPRS data, the transmission is handed off to cell **78** in the partner network. In step **304**, BSC **82** which controls cell **78,** receives data from SGSN **74**, including the IMSI for MS **30,** identifying it as belonging to the home network. In step **306**, BSC **82** sends a message to SGSN **94** of the home network, indicating the presence of MS **30** in the partner network, with an agreed upon indicator specifying cell **78**. The home network then checks its list of cells in the neighborhood of cell **78**, and in step **308**, forwards a message through GGSN **96**, PDN **80**, and GGSN **76**, to SGSN **74**, including information regarding home network cells **88** and **90**, both bordering cell **78**. In step **310**, SGSN **74** forwards the information to BSC **82**, which, in step **312**, then delivers a new packet measurement order to remove partner network cells **84** and **86** from the MS **30** measurement list, and replaces them with home network cells **88** and **90**. If MS **30** continues to travel in the direction of home region **50**, then as shown in step **314**, MS **30** hands over into cell **90** of the home network.

[0030] Figure 9 outlines another embodiment of the present invention. In step **400**, BSC **72** receives information from MS **30**, including the international mobile system identity (IMSI). This information is forwarded to SGSN **74**, which sets a flag designating MS **30** as belonging to the home network, in step **402.** Referring again to Figure 6a, when MS **30** enters cell **78** in the partner network, in step **404**, SGSN **74** sends data including the IMSI for MS **30** to BSC **82**, which alerts the BSC to the fact that MS **30** belongs to the home network. In step **406,** as illustrated in Figure 6b, MS **30** approaches the border between partner region **32** and home region **50**, and forwards measurements from the partner network cells **84** and **86** to BSC **82**. From the signal strength measurements, BSC **82** determines that a handover condition exists for MS **30**, which is flagged as a subscriber to the home network. In step **408**, BSC **82** determines which reporting cells on the measurement list of MS **30** do not belong to the home network, and in step **410**, BSC **82** delivers a packet measurement order which removes partner network cells **84** and **86** from the MS **30** measurement list. In step **412**, MS **30** detects cells **88** and **90** and adds them to an updated measurement list. If MS **30** continues to travel in the direction of home region **50,** in step **414** it hands over into cell **90** of the home network, based, for instance, on superior signal strength or better availability, with respect to nearby home network cell **88**.

[0031] Thus, according to the above disclosed embodiments, calls to home mobile network subscribers entering a home region from a partner region, are more likely to be handed over to the home network, rather than continue to be routed through the partner mobile network. It follows then that the home mobile network is able to recover more revenue from subscribers whose calls might otherwise have continued to be charged by the partner network.

[0032] The foregoing disclosure of the preferred embodiments of the present invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many variations and modifications of the embodiments described herein will be apparent to one of ordinary skill in the art in light of the above disclosure. The scope of the invention is to be defined only by the claims appended hereto, and by their equivalents.

[0033] Further, in describing representative embodiments of the present invention, the specification may have presented the method and/or process of the present invention as a particular sequence of steps. However, to the extent that the method or process does not rely on the particular order of steps set forth herein, the method or process should not be limited to the particular sequence of steps described. As one of ordinary skill in the art would appreciate, other sequences of steps may be possible. Therefore, the particular order of the steps set forth in the specification should not be construed as limitations on the claims. In addition, the claims directed to the method and/or process of the present invention should not be limited to the performance of their steps in the order written, and one skilled in the art can readily appreciate that the sequences may be varied and still remain within the spirit and scope of the present invention.